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VISUAL IDENTITY MATCHING AND AUDITORY-VISUAL MATCHING: A PROCEDURAL NOTE

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After preliminary computerized training on visual-visual identity matching, a 5-year-old boy with autism (Sam) was given visual-visual and auditory-visual matching-to-sample tests with new stimuli. He did well in matching dictated name samples to 20 pictures, 26 printed upper case letters, and 9 single-digit numbers. In matching the visual stimuli (pictures, letters, or numbers) to themselves, however, he did not perform well. We then increased the number of picture comparisons per trial from two to three. In tests after this three-comparison training, Sam correctly matched on 95% of the original 20-stimulus, four-comparison, identity-matching test trials. He went on to demonstrate accurate identity matching of the numbers, letters, and new pictures. In identity-matching tests on the table top, he performed poorly until the stimulus array was made to resemble the stimulus arrangement on the computer. These findings showed that seemingly small procedural changes can influence performance and demonstrated that successful auditory-visual matching does not guarantee proficiency in visual-visual identity matching.

DESCRIPTORS: matching to sample, conditional discrimination, crossmodal matching, autism

The present study began as an attempt to use computerized matching-to-sample procedures to evaluate and, where needed, to improve a child's performance on a variety of preacademic skills. Initial screening tests demonstrated that the child, Sam, did considerably better on auditory-visual matching than on visual-visual identity matching. Because identity matching is widely regarded as a test of relational discrimination (e.g., Dube, Iennaco, & McIlvane, 1993; Dube, McIlvane, & Green, 1992), one might expect individuals who could not do visual identity matching to be unable to do auditory-visual matching that involved those same stimuli. Identity-matching procedures are also used not just for testing but to teach children basic discriminative and relational

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performances. (For evidence of a developmental progression in which auditory-visual performances develop before visual-visual performances, however, see Daehler, Lonardo, & Bukatko, 1979; Rosenberger, Stoddard, & Sidman, 1972. Constantine & Sidman, 1975, have also reported better performance on delayed auditory-visual matching than on visual-visual identity matching.)

One possible explanation for the pattern of test performances we observed was that even though Sam was capable of the required visual discriminations (as shown by his auditory-visual matching performances), he had not yet learned to do visual-visual identity matching, especially not in the particular computerized format we were using. To test this possibility, we instituted procedures that were aimed at teaching Sam to do identity matching with pictures.

METHOD AND RESULTS

Participant

The participant, Sam, was a 5-year-old boy with a diagnosis of autism who was enrolled in The New England Center for Children's intensive behavioral preschool. Just before the school year started, a speech-language pathologist not associated with Sam's school administered several standardized tests, which produced the following age equivalents: Peabody Picture Vocabulary Test, 3 years 2 months; Expressive One-Word Picture Vocabulary Test, 3 years 2 months; Preschool Language Scale, auditory comprehension, 2 years 11 months, expressive communication, 3 years 1 month; Test of Auditory Comprehension of Language, 3 years 4 months to 3 years 7 months. An independent pediatric neuropsychologist also evaluated Sam and reported age equivalents of 3 years or below on all subtests of the Wechsler Preschool Scale of Intelligence except on object assembly, which yielded an age equivalent score of 4 years 4 months. Teachers reported that Sam had demonstrated identity matching via a sorting task and auditory-visual word-picture matching via tabletop discrete-trial procedures. We did not confirm the validity of those reports.

General Procedure

Setting and apparatus. All teaching and testing (until a final generalization test) took place in a specialized computer room, approximately 5 m by 4 m, at the New England Center. The computer used in this study was a Macintosh LC630© that was separated from the other computers in the room by a partition. The teacher (first author) and Sam sat in front of the computer within a three-sided cubicle. After Sam completed each set of trials, the teacher set up the computer for the next set. The teacher also presented the edible reinforcers after each correct trial (see below).

The computer presented and removed stimuli, managed contingencies, and recorded data. Visual stimuli, black figures on a white background, were presented on an Apple Multiple Scan© 15-in. monitor in which a Microtouch© touch-sensitive screen had been installed. Visual samples appeared in the center of the monitor screen, and comparisons appeared in the corners of a rectangle (13 cm by 19 cm) in which the sample was centered. Stimuli occupied 4-cm square areas, or "keys," with invisible borders. When Sam touched a key, the computer program recorded the location of each touch as being within a particular key; touches outside the key areas had no effect on the recording system.

The matching-to-sample procedure. After an intertrial interval of 1.5 s, each trial began with the presentation of a sample stimulus. When the sample was visual, it appeared in the center key. When the sample was auditory (presented by the computer from previously prepared sound files), it was accompanied by a blank center key. Touches to the center key after a sample presentation produced comparison stimuli on the outer keys. Visual samples remained on the center key, and auditory samples continued to be repeated until the participant touched a comparison key; the procedure was always simultaneous matching to sample. Comparison stimulus locations varied unsystematically across trials. Correct comparison selections produced a melodic tune and six edible items, from which Sam chose one. After an error, the intertrial interval was the only consequence. This differential reinforcement procedure was followed during preliminary training and all subsequent testing phases.

Preliminary Training

Only visual stimuli were presented on the computer screen during preliminary training; not until the first series of tests (described below) was Sam exposed to auditory-visual tasks. On each trial during the first phase of preliminary training, the screen contained only one stimulus, a plus symbol within a white square outline on a black background. The symbol was presented in one of the four outer key locations, which varied unsystematically across trials. Touching the symbol produced a melodic tune and an edible item. From trial to trial, the background gradually faded from black to white. The intertrial interval was 1.5 s.

Sam was then given preliminary visual-visual match-to-sample training with three stimuli: line drawings of a dog, a house, and a tree. On each trial, one of these stimuli was the sample and two were comparisons. One comparison—the correct choice—was identical to the sample and the other was an incorrect choice. A delayed-cue procedure was used. At first, the incorrect choice disappeared after 0.1 s, leaving only the correct comparison stimulus; after each subsequent correct trial, the incorrect comparison remained for a fraction of a second longer before disappearing; after the delay reached 2 s, the increase took place in steps of 0.5 s up to a maximum of 15 s. Eventually, Sam chose the correct comparison without a cue while an incorrect alternative was still visible. When performance met a criterion of 20 consecutive correct unprompted choices, the stimuli were changed to three new pictures—line drawings of a pig, a shirt, and a chair—again, with the delayed-cue procedure. After Sam had once more chosen correctly on 20 consecutive unprompted trials, preliminary training ended and tests for several preacademic performances were administered. The delayed-cue procedure was not used during tests.

The First Series of Tests

In these tests, four comparison stimuli were presented on each trial (preliminary training had used only two comparisons per trial). Correct choices always produced the reinforcer. Figure 1 presents the data from this and subsequent series of tests. In the first series of tests, Sam scored poorly on visual-visual identity matching—matching visual samples to identical comparisons—but did much better when matching auditory samples to those same visual comparison stimuli. When he was required to match 20 dictated picture names to comparison pictures, he scored 90%, but in matching these same pictures to their identical comparisons, he scored only 20%. In matching the nine dictated single-number names to number comparisons, he scored 97% and 100% (two tests), but in matching each of the numbers to an identical comparison, he scored 37% and 30% (two tests). On tests with the 26 upper case letters, his scores in matching the dictated letter names to the letters were 81% and 92% (two tests), but his identity-matching scores were 50% and 31% (two tests).

To reduce the likelihood that the teacher was giving unintended cues to Sam during the auditory-visual matching tests, another

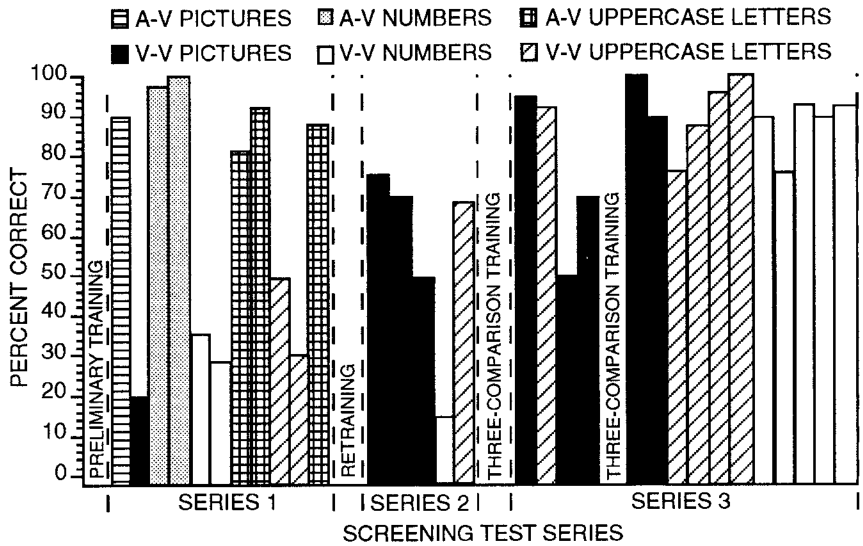

Figure 1. Test scores for visual-visual identity matching (V-V) and auditory-visual matching (A-V) of 20 pictures, numbers 0 through 9, and upper case letters A through Z during the first, second, and third series of tests. The final test in Series 1 was conducted by a different teacher than in the other tests. The training phases (see text for details) are also indicated.

teacher conducted an auditory-visual test with the upper case letters. In this test, Sam scored 88% correct.

Retraining: Elimination of the Delayed Cue

After the first series of tests, we reexamined the preliminary training procedures. We found that after Sam's performance had attained the accuracy criterion in the delayed-cue procedure, we had not ensured that he would still meet the criterion without having had the assistance of the delayed-cue procedure at the beginning of the session. Perhaps he had still needed some minimal prompting with the delayed cue to get him started in each session. We therefore implemented the delayed-cue training procedure again. The stimuli were the same (black and white line drawings of a dog, house, and tree), and the procedure was the same as described above in *Preliminary Training.*

Once Sam's performance met the accuracy criterion this time, however, he was given the same matching-to-sample task without the delayed-cue procedure. He now demonstrated perfect accuracy even without additional help from the delayed cue. Then, a second series of identity-matching tests with pictures, numbers, and letters was given, as in the first series of tests.

The Second Series of Tests

After the retraining, Sam's identity-matching performances improved slightly. In three tests of picture identity matching, he scored 75%, 70%, and 50% correct; his accuracy started higher than before but decreased from test to test. He scored only 17% with the nine numbers and 69% with the upper case letters. Although his performances had improved somewhat, Sam remained considerably less proficient in visual-visual identity matching to sample than he had been in auditory-visual matching.

Training with Three Comparisons per Trial

Three potentially important differences between our original training and test procedures were (a) the introduction of new stimuli during the tests, (b) a larger number of stimuli in each of the tests than in pretraining, and (c) the use of four rather than two comparison stimuli during each test trial. The next training phase constituted an attempt to reduce the influence of the third possible factor by increasing the number of comparison stimuli gradually.

On preliminary training and retraining trials, Sam had to select the correct stimulus from the two comparisons that were presented to him. On test trials, he had to make a selection from among four comparison stimuli. Although the change from two to four comparison stimuli per trial had not caused Sam any difficulty when the samples were dictated, the increase may have been responsible for his lower accuracy when samples were visual. After the second test series, therefore, we moved back from four to three comparison stimuli per trial. Instead of returning to the original three training stimuli and the delayed-cue training procedure, however, we stayed with our standard picture-picture test procedure, using the same 20 pictures as in the earlier tests; no other stimuli were presented during three-comparison training. Except for the absence of numbers, letters, and auditory stimuli, the only difference between this training procedure and the previous two series of tests was the number of comparison stimuli that were presented on each trial. In this training (not shown in Figure 1), Sam had considerable difficulty at first, achieving consecutive scores of only 75% and 55% correct. In the next two tests, however, he scored 85% and 95%. After this, he received his third series of tests with four comparisons per trial.

The Third Series of Tests

In the first test in this series, picture-picture identity matching, Sam achieved a score of 95%. In the second test, identity matching of the 26 upper case letters, he scored 92% correct, even though he had not received three-comparison training with these stimuli. In repetitions of the picture-picture matching tests, however, Sam did not maintain these high scores, decreasing to 50% and 70% correct. He was therefore returned to picture-picture matching with three comparisons per trial and was maintained on that procedure, scoring 90%, 95%, and 95% correct (not shown in Figure 1). After this additional experience with three comparisons per trial, he was again given the tests with four comparisons per trial.

Now, two tests of picture-picture matching yielded scores of 100% and 90% correct. Then, identity-matching tests with pictures and upper case letters were alternated several times. In these tests, picture identity matching was maintained at 90% or better (not shown in Figure 1), and consecutive letter-letter matching tests yielded scores of 77%, 88%, 96%, and 100%.

Sam then continued to maintain high performance levels on picture-picture matching when these tests were alternated with number-number matching (the nine single numbers). On consecutive number-number matching tests, Sam scored 90%, 77%, 93%, 90%, and 93%, even though he had not been given three-comparison experience with those stimuli.

Generalization Tests

To determine whether Sam would demonstrate accurate identity matching with stimuli he had not seen before, he was given three additional computerized tests with new pictures (not shown in Figure 1). The pictures in the first of these generalization tests were different versions of the same 20 objects as before, but again, they were black-and-white line drawings. In the second test, the stimuli were pictures of different objects than before, but this time black-and-white photographs were used. The third test used different versions of those same photographed objects, and this time the photographs were in color. (The computer software was capable of incorporating colored photographs as well as line drawings as both samples and comparisons.) In all of these tests, Sam maintained criterion performances, scoring 95%, 100%, and 100%. Although no baseline assessment of the generalized performances had been conducted, it seems unlikely that Sam's original failures at identity matching would have been restricted to the particular pictures, numbers, and letters that we had used in the original test series.

Additional generalization tests (not shown in Figure 1) were carried out in the classroom setting, on the tabletop. The stimuli in all of these tests were black line drawings of objects, different from those that had been presented on the computer monitor. In the first two tests, Sam scored 40% and 67%. In these tests, however, the samples and comparisons were not presented in a format similar to the computer's display. The format of the third and fourth identity-matching tests was then modified to resemble the stimulus arrangement on the computer. At the start of a trial, a sample was centered by itself on a piece of white paper. After Sam touched the sample, that paper was removed, revealing another paper that contained the comparisons in a square pattern with the sample in the center, like the keys on the computer. On these tests, Sam scored 90% and 100% correct. Each response was scored separately by the first author and a second data recorder; interobserver agreement was 100%.

DISCUSSION

Sam demonstrated a high level of skill at auditory-visual matching but performed poorly in visual-visual identity matching, which is often considered to be a test for the visual discrimination skills that are required for auditory-visual matching. His success in auditory-visual matching demonstrated, however, that he was capable of discriminating the visual stimuli. We therefore investigated the possibility that his problem lay in some aspect of our teaching and testing procedures.

Subsequent success in teaching Sam to do identity matching indicated strongly that his earlier deficient performances had arisen from our specific teaching and testing procedures. A critical aspect of those procedures turned out to be the number of comparison stimuli that were presented on each trial: The original matching-to-sample teaching procedures used only two comparison stimuli per trial, but the test procedures used four comparisons. When we increased the number of comparison stimuli more gradually, going from two to three to four, Sam was able to maintain a high level of picture-picture identity-matching accuracy, to perform well in identity matching of numbers and letters that he had previously experienced only in tests with two comparisons per trial, and to generalize this identity-matching skill to new stimuli that we had not previously used at all. It is possible, of course, that continued training with the four-comparison array might have produced the same results, even without the intervening three-comparison phase.

We hope our findings will encourage researchers and teachers to question their procedures when a child does not exhibit a specific type of stimulus control. There are several reasons why the use of only two comparisons per trial during training can produce negative results on subsequent generalization and other types of tests (Carrigan & Sidman, 1992; Johnson & Sidman, 1993; Sidman, 1987). For example, a participant who learns not to select the stimulus that matches the sample but, instead, to reject the one stimulus that does not match will be at a loss when faced with more than one nonmatching stimulus. Also, some participants, particularly young children and individuals with severe learning difficulties, may not have learned to scan a display that contains many alternatives; that skill may have to be taught explicitly.

More generally, the initial screening tests in this study demonstrated that a participant's ability to match auditory samples to visual comparisons does not guarantee that the participant will do identity matching with those same visual stimuli. Although visual discrimination is a prerequisite for auditory-visual matching, visual-visual identity matching involves many factors other than stimulus discriminations, including procedural features that generate or require behavior that the reinforcement contingencies do not specify explicitly—like selection of positive or rejection of negative comparisons and effective scanning of the display. Even the final generalization tests on the tabletop demonstrated that small display changes may lead to marked changes in matching-to-sample performance. It will not do to assume that crossmodal matching implies adequate identity matching under the particular procedures that one is using.

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